ERWIN SUTLIFF
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116 005 007
Rev. 2

ALNOR®
INSTRUMENT COMPANY

OWNERS MANUAL

TYPE 7000
DEW POINTER

ALNOR INSTRUMENT COMPANY
7301 N. CALDWELL AVE.
NILES, ILLINOIS 60648

CAUTION

The Alnor Dew Pointer contains a radioactive foil impregnated with 7 microcuries or less of Radium 226. This foil is used to ionize gases and is contained in the fog chamber, part no. 7060A. Your Dew Pointer has been designed so that in operating it, you do not have to open the Fog Chamber and thereby come in contact with the radium foil. Since opening the Fog Chamber could degrade the performance of the Dew Pointer and might also harm your health, both caps have been locked and sealed on the Fog Chamber. In no event should you touch the radium foil. See pages 7 and 19 of this manual for further information concerning the Fog Chamber and the servicing of it.

ALNOR TYPE 7000 DEW POINTER

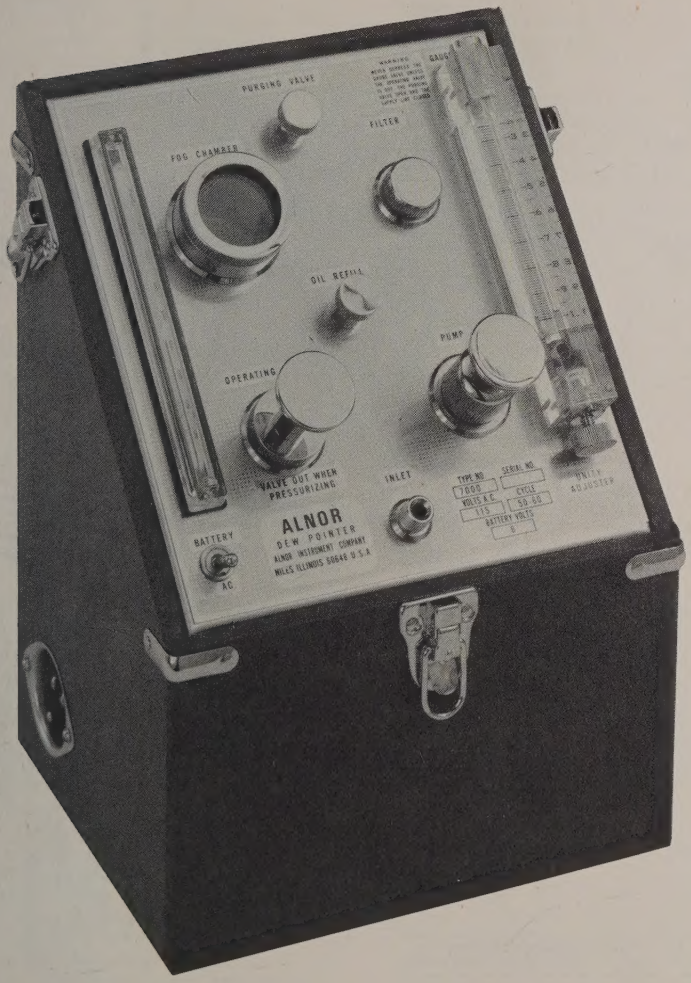

FIG. 1

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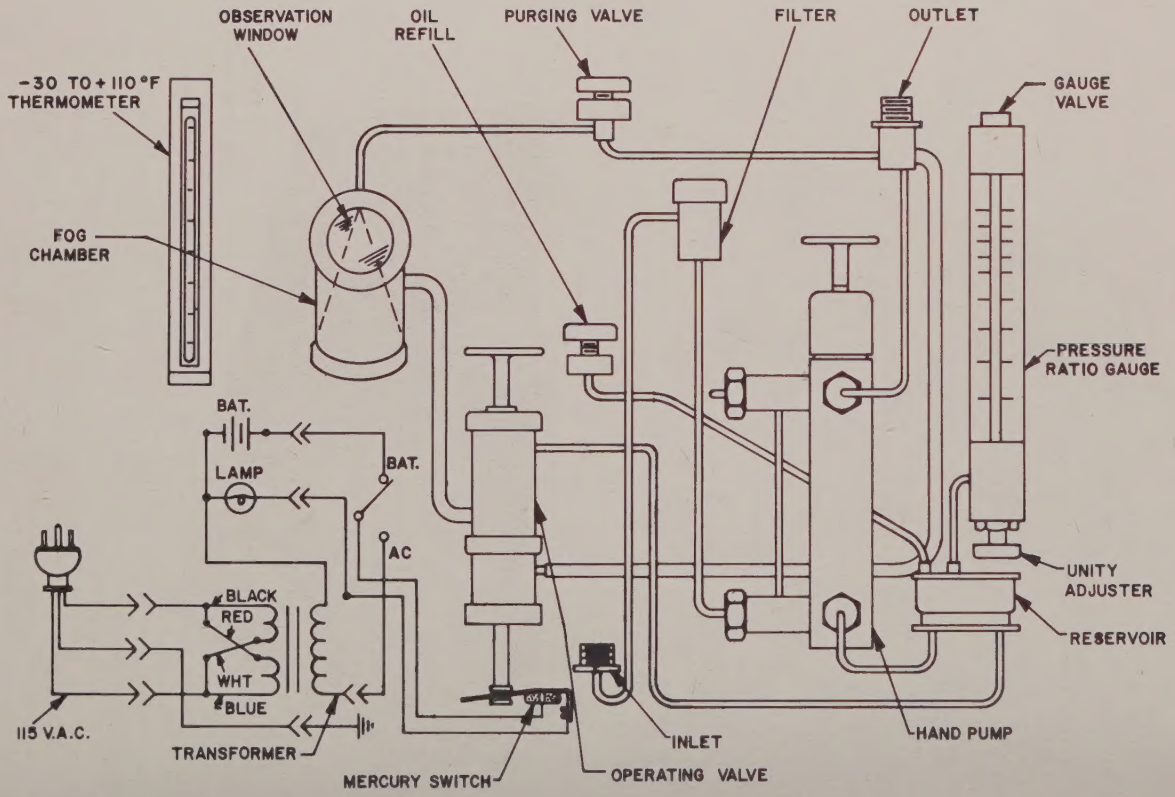

TYPE 7000
FIG. 2

SCHEMATIC DIAGRAM

INSTRUCTIONS FOR "ALNOR" TYPE 7000 DEW POINTERS

Introduction

The Alnor Dew Pointer is used to determine the dew point of a gas-water vapor mixture. When such a mixture is gradually cooled, some temperature is reached at which water will begin to condense out. By definition this temperature is known as the "dew point." It is the "saturation temperature" at which relative humidity is 100%.

Finding the dew point is a convenient way of determining and expressing the absolute humidity of air and other gases.

The 7000 instrument is available in three nominal dew point ranges as follows:

Type	*Nominal Dew Point Range*
7000H	Room Temp. to -20°F.
7000U	Room Temp. to -80°F.
7000L	0°F. to -80°F.

The actual range of each instrument is dependent on the temperature of the Dew Pointer and the gas being tested in addition to the range of the pressure ratio gauge.

During shipment, air bubbles become entrapped in the red fluid of the pressure ratio gauge. Before using the Dew Pointer, please refer to the Maintenance & Service Notes (p. 19, para. 2) and follow the instructions for removing the air bubbles in case some are hidden in the reservoir.

Connections

When A-C power is required, use the line cable furnished and connect the Dew Pointer to a convenient source of 50 or 60 Hz. at the voltage shown on the nameplate of the instrument.

Connect the inlet fitting of the Dew Pointer (lower edge of panel) to the source of gas. Stainless steel tubing is best although Tygon or Teflon tubing may be used. Fully tighten all connections.

When the pressure at the source is appreciably above atmospheric, put a shut-off valve in the supply line to hold down the pressure applied to the Dew Pointer. When the gas being tested is dirty, use an external filter (#7109B) which requires the same filter medium (#7109) as the filter in the panel.

The outlet of the Dew Pointer (rear) may be connected to a suitable waste line if desired. See note 11 on page 7.

Adjustments

Before operating the Dew Pointer, a Unity Adjustment must be made on the Pressure Ratio Gauge as follows:

1. Place operating valve in out position.
2. Open Purging Valve to be sure there is no pressure in the instrument.
3. Depress the Gauge Valve and turn the Unity Adjuster until the bottom of the meniscus is in line with the 1 mark.
4. Release the Gauge Valve.

Close the purging valve and pump up the instrument until the pressure ratio gauge reads about .5. Open the purging valve. If the meniscus does not return to the 1 mark after a few moments, repeat the unity adjustment as above. It sometimes happens that after a period of prolonged idleness the flexible diaphragm in the oil reservoir takes a set, but the above operation will correct the condition.

If the source of gas is above atmospheric pressure be sure to shut off the source of pressure before making the unity adjustment.

WARNING: Never depress the gauge valve unless the operating valve is out and the purging valve open, and the supply valve closed.

The unity adjustment should be checked frequently—particularly if the instrument temperature or barometer pressure is fluctuating.

Operation

Open the purging valve. Pull out the operating valve.

Place switch in "A.C." or "BATTERY" according to the power source to be used.

Pump the gas to be tested thru the instrument to flush out all the old gas in the Dew Pointer (at least 10 to 15 strokes of the pump). When very low dew points are to be tested more thorough purging is required. The Dew Pointer will give the correct dew point of the sample in the instrument. Be sure to flow enough gas thru so that the gas in the instrument is the gas you want to test.

Close the purging valve. Pump a sample of gas in the instrument. Look into the observation window and press down on the operating valve.

Depressing the operating valve actually performs three operations in the following sequence.

1. Closes line from the inlet and pressure ratio gauge.
2. Turns on the light.
3. Rapidly opens the line from fog chamber to the atmosphere.

If a fog (cone of sunbeams) appears, it indicates the gas was cooled below the dew point and subsequent trials should be made at lower pressures (numerically higher pressure ratios). Make similar trials at each higher major division on the pressure ratio gauge until one reading is obtained where no fog appears. Then "Close In" on the end point, i.e. maximum pressure ratio that will produce a fog.

The object of the operation of the Dew Pointer is to determine the pressure ratio that will just produce a fog. This is called the "End Point."

If, on the first trial no fog appears, it indicates that the gas was not cooled down to the dew point. It is apparent, therefore, that a lower pressure ratio (higher pressure) is required to produce sufficient cooling to reach the dew point. Subsequent trials should, therefore, be made at each lower (higher pressure) major division on the Pressure Ratio Gauge until one trial is obtained in which a fog appears. Having located one point where there is a fog and one where there is no fog, "close in" on the end point. It is easily possible to get the difference between the appearance and non-appearance of the fog to be only .01 apart, as read on the pressure ratio gauge.

After any trial in which a fog appears, it is advisable to take several strokes on the pump to purge the fog chamber of any droplets of moisture that fail to re-evaporate promptly.

When making the last trials near end point, permit 10 to 15 seconds to lapse after pumping the sample into the instrument before pushing down the operating valve to permit the sample to come to the temperature of the fog chamber.

The experienced operator will find he can determine the end point after a few trials since the density of the fog on any given trial is a valuable clue to how far he is from the end point.

If the approximate value of the dew point is known, the reverse operation of the Dew Point Calculator will indicate the approximate Pressure Ratio which should be used for the initial trial. This will further reduce the number of trials required to achieve the end point.

After determining the end point, take the mean between the minimum pressure ratio that fails to produce a fog and the maximum pressure ratio that produces a fog. Use this value with the initial temperature as read on the thermometer and the Q value for the gas being tested to compute the dew point with the "Alnor" Dew Point Calculator.

Q Values

The Q value of a gas is a natural constant of the gas. It is representative of the cooling power of the gas.

The Q value of the gas being tested must be known to arrive at the dew point of the gas. Values of common gases are given below.

TABLE 1

		Q
Air		.285
Argon	A	.400
Carbon Dioxide	CO_2	.225
Carbon Monoxide	CO	.285
Dissociated Ammonia		.285
Endothermic		.285
Ethane		.165
Exothermic		.285
Helium	He	.400
Hydrogen	H_2	.285
Methane	CH_4	.240
Nitrogen	N_2	.285
Oxygen	O_2	.285
Propane		.139
Other Gases	Refer to chemical Handbooks	
Gas Mixtures	Refer to the Appendix.	

Use of the Dew Point Calculator

To use the Dew Point Calculator the following values must be known.

1. Q value of the gas.
2. The initial temperature of the gas as read on the thermometer on the Dew Pointer.
3. The pressure ratio required to just produce a fog.

If the Q. value is .2855 proceed as follows:
Set arrow 1 at initial temperature, °F or °C, on scale E.

Opposite the observed pressure ratio on scale D, read Dew Point on scale E.

EXAMPLE: Air is being tested so the Q value is .2855. The thermometer reads 75° F. A fog appears at a pressure ratio of .46 but does not appear at .47; therefore the end point is .465.

1. Set arrow 1 opposite 75 on scale E.
2. Opposite .465 on scale D, read the dew point temperature of -29.7° F. on scale E.

If the Q value is not .2855 proceed as follows:
Set arrow 1 at initial temperature, °F or C°, on scale E.

Set arrow 2 at Q value on scale A.

Opposite the observed pressure ratio on scale B, read equivalent pressure ratio on scale C. Opposite the equivalent pressure ratio on scale D, read the dew point temperature on scale E.

EXAMPLE: Pure methane is being tested. The Q value is .24. Initial temperature is 80° F. A fog appears at .51 but does not appear at .52 so the end point is .515.

1. Set arrow 1 at 80° F. on scale E.
2. Set arrow 2 at .24 on scale A.
3. Opposite .515 on scale B, read equivalent pressure ratio as .57 on scale C.
4. Opposite this equivalent pressure ratio appearing on scale D, read dew point temperature as 0° F. on scale E.

Principle of Operation

The principle of operation of the Dew Pointer is fundamental and simple. A thorough understanding of this principle will aid in the operation of the instrument.

The gas to be tested is pumped into the observation chamber at some pressure above atmospheric. The chamber is then rapidly exhausted to the atmosphere with a resultant expansion and cooling of the gas. If the cooling is sufficient to reduce the temperature of the gas to, or below, the dew point, water vapor will condense out in the form of a fine mist or fog. This fog is readily observable thru the observation window. Because of a light located below the fog chamber focused at the top of the chamber, the fog appears as a cone of sunbeams.

Successive trials will determine the minimum initial pressure which will produce a fog. The gas is then being cooled just to the dew point. The final temperature after expansion (the dew point) which is maintained for too brief an interval to measure, is then computed by means of the equation for an adiabatic expansion. The expansion is adiabatic (no heat added or subtracted during the process) because it is so rapid.

The following equation expresses a fundamental relationship between the pressure and temperature during an adiabatic expansion.

$$\text{Final Temp.} = \text{Initial Temp.} \left[\frac{\text{Final Pres.}}{\text{Initial Pres.}}\right]^{\frac{K-1}{K}}$$

where all values are in absolute units and

$$K = \frac{\text{specific heat at constant pressure}}{\text{specific heat at constant volume}}$$

For the "Alnor" Dew Pointer, the final temperature is the dew point temperature ($t_{D.P.}$). The ratio (P.R.) between the final pressure and initial pressure can be read directly on the pressure ratio gauge without necessity of knowing the individual quantities. By definition $Q = \frac{K-1}{K}$

The equation for an adiabatic expansion can, therefore, be converted into the following form for our purpose.

$$t_{D.P.} = (t_i + 460)\ (P.R.)^{Q} \quad -460$$

when the temperatures are in ° F.

Since the initial temperature (ti) is read on the thermometer, P.R. is read on the pressure ratio gauge, and Q is a constant that depends on the gas being tested, it is apparent that the solution for the dew point temperature ($t_{D.P.}$) is perfectly straight-

forward though somewhat cumbersome. In actual use, a calculator is supplied that makes the above computation extremely simple.

The formation of a visible fog at the dew point temperature depends on the presence of dust in the gas to act as nuclei around which the droplets can form. In practically all cases dust is present. If, however, gas is completely dust free (such as gas produced by fractional distillation) it would be possible to cool the gas below the dew-point temperature without condensing the moisture, if some substitute for the dust particles were not provided. All ALNOR Dew Pointers are therefore equipped with a piece of radioactive material built into the fog chamber. The radiation ionizes the gas in the chamber and the ions act as nuclei around which the droplets can form and build up to visible size. These Dew Pointers will, therefore, give the correct result regardless of the presence or absence of dust.

Operating Notes

1. When working with dry gases having low dew points, it should be remembered that extremely small quantities of water vapor are involved. It should further be remembered that the instrument can only give the result for the gas sample that is actually in the fog chamber. It is for this reason that it is extremely important that the gas does not pick up or lose moisture in the process of being transferred from its source to the fog chamber:

2. Stainless steel tubing is the most satisfactory material for connecting the instrument to the source of gas because it is not hygroscopic. The use of rubber tubing will almost certainly contaminate the gas sample. A dense neoprene or vinyl tubing is satisfactory except for very dry gases.

It is for the same reason that the filter material should be replaced occasionally.

If an appreciable quantity of dust is allowed to accumulate in the filter, the moisture content of the gas may be altered as it passes through the filter.

3. The built in hand pump is double acting. The gas flowing on the top side of the piston is discharged through the outlet without flowing through the fog chamber.

4. The only function of this gas is to keep the pump barrel dry and avoid contamination of the test gas.

5. Thorough initial purging of the instrument is important. Reference to the vapor density curves (figs. 7 & 8) show that the vapor density at 50°F. is .59 lbs. per 1000 cu. ft. and the vapor density at -70°F. is only .0019 lbs. per 1000 cu. ft. If the instrument were originally filled with air having a dew point of 50°F. and only .1% of the original volume were left in the chamber due to inadequate purging the instrument would give an indication that was 3° high when testing a sample of gas having a dew point of -70°F.

6. It is, of course, important to have all connections tight on the inlet side of the instrument. In some cases momentary negative pressures can be caused in the inlet line by the operation of the hand pump. If there were a leak in the inlet line atmospheric air could flow in and add moisture to the sample during these short periods of negative pressure. Furthermore, the vapor pressure of the air is generally higher than the vapor pressure of the gas being tested. It is, therefore, possible for water vapor to flow in through a leaky connection even when the gas pressure is above atmospheric.

7. If the gas is drawn from a high pressure, as from a bottle of compressed gas, a pressure reducing valve or a needle valve will be needed ahead of the Dew Pointer. A connecting line of adequate size is needed. Try to obtain ¼" stainless steel tubing since it has the lowest absorption of moisture and hence will purge dry in the shortest time. Do not use capillary tubing under any conditions. Do not use an extremely high rate of flow during purging. The excessive flow rate or the use of capillary tubing may remove some moisture from the gas before it enters the Dew Pointer.

8. The above caution does not imply that the flow rate during purging is critical. If the flow is such that the fluid in the pressure ratio gauge stands at .95 to .98, it is entirely satisfactory.

9. Flow rate must be great enough to supply the needs of the hand pump and to keep outside air from entering the sampling tubing and connections. There should never be pressure below atmospheric in the sampling line.

10. Notice in Figure 2, that there is a by-pass tube between the inlet and outlet valves of

the hand pump. When there is a little positive pressure on the inlet fitting, there will be a continuous flow from the outlet fitting of the Dew Pointer.

11. If a hazardous or toxic gas is being measured, it is permissible to connect a suitable discharge hose to the outlet fitting of the Dew Pointer to carry the gas away. This hose should be sufficiently large to permit the pressure at the outlet fitting to remain essentially atmospheric. Avoid trying to test a gas that will corrode copper or brass.

12. A sample of gas may be drawn from a furnace if the dew point of the sample is below the temperature of the Dew Pointer. The sampling tube may be a piece of ¼" Inconel which is extended to the Dew Pointer by the same kind of tubing or by a length of stainless steel tubing as mentioned in Para. 7 above.

Concerning Radio-Active Material within the Fog Chamber

As mentioned on page 6, an ionization source is located inside the Fog Chamber of the Dew Pointer to provide nuclei around which droplets of moisture can form. This source is properly described as a fixed sealed source containing 7 microcuries or less of Radium 226.

Legislatures in most of the United States have passed bills to protect their citizens from the indiscriminate use of radioactive materials. While the restrictions and requirements vary from one state to another, one of the most cautious and demanding states is Illinois in which Alnor operates under license from the Illinois Department of Public Health. Markings required are (1) a warning label on the body of the Fog Chamber and (2) a larger warning label on the outside of the Dew Pointer case. Both the DOT and IATA transport regulations require this label and it must not be removed.

The amount of radioactive material within the Dew Pointer is so small that no radiation hazard exists for the user. Do not open the Fog Chamber and never touch the radium foil. When the chamber needs cleaning, this should be done only by the factory or an authorized Service Station. The Dew Pointer is exempt from the semiannual leak test because of the improved manufacturing methods and the safety precautions that are being emphasized.

To ship the instrument, be sure the label is still on the rear of the case. Use a sturdy packing box measuring at least 15"x15"x18" and position the Dew Pointer in the center of this case. No warning label is needed on the outside of this shipping box but the shipping papers should describe the shipment as follows: "One fixed sealed cource having 7 microcuries of Radium 226 in solid form."

Disassembly of the Fog Chamber or disposal of it or the radium foil should not be attempted without specific authority from your radiological health agency and then only by properly trained personnel. BE SAFE AND SURE — RETURN THE DEW POINTER TO ALNOR FOR SERVICE OR DISPOSAL OF THE RADIUM.

Q Value of Mixtures

A mixture of gases can be treated as a single gas if the proper constants are established. The value of Q can be computed by one of the following methods.

METHOD 1—MASS BASIS

Since the effect that the specific heat of an individual gas has on the specific heat of the mixture is proportional to the mass of the gas present the following equation can be written.

$$(1)\ C_{pm} = \frac{M_x}{M_m}C_{px} + \frac{M_y}{M_m}C_{py} + \text{----} + \frac{M_z}{M_m}C_{pz}$$

$$(2)\ C_{vm} = \frac{M_x}{M_m}C_{vx} + \frac{M_y}{M_m}C_{vy} + \text{----} + \frac{M_z}{M_m}C_{vz}$$

Where

C_{pm} = Specific heat at constant pressure of the mixtures
C_{vm} = specific heat at constant volume of the mixture
C_{vx}, C_{vy}, & C_{vz} = specific heat at constant volume of each gas.
C_{px}, C_{py}, & C_{pz} = specific heat at constant pressure of each gas.
M_m = total weight of the mixture
M_x, M_y & M_z = weight of each gas

Specific heats are expressed in heat units per weight unit per temperature unit such as B.T.U. per pound per ° F.

Then

$$(3)\ K_m = \frac{C_{pm}}{C_{vm}}$$

and

$$(4)\ Q_m = \frac{K_{m-1}}{K_m}$$ or from figure 3

where

K_m = K value for the mixture
Q_m = Q value for the mixture

It is only necessary to insert the proper values in equations (1) and (2) and then solve.

EXAMPLE FOR METHOD 1

A mixture of gas is known to be composed of the following:

20% by weight CH_4
40% by weight CO_2
40% by weight N_2

Find the value of Q

Substituting in equations 1 and 2
$C_{pm} = .2\,(.593) + .4\,(.200) + .4\,(.247) = .2974$
$C_{vm} = .2\,(.450) + .4\,(.155) + .4\,(.176) = .2244$

Then

$$K_m = \frac{.2974}{.2224} = 1.337$$

and

$$Q_m = \frac{.337}{1.337} = .252$$

METHOD 2—VOLUMETRIC BASIS

When a mixture of gases is analyzed with an Orsat apparatus the percentages of each component are determined on a volumetric basis. It is, therefore, essential that these volumetric percentages be converted to weight percentages before Method 1 can be used.

$$(5)\ \frac{M_x}{M_m} = \frac{Xd_x}{d_m} \qquad \frac{M_y}{M_m} = \frac{Yd_y}{d_m};\ \text{etc.}$$

where

X = percent by volume of gas X
d_x = density of gas X
d_m = density of the mixture

Notice that any condition of temperature and pressure and any units of density can be used provided the same conditions and units are used thruout.

Equations 1, 2, 3, & 5 can be combined and multiplied by $\frac{d_m}{d_m}$ to following simple form.

$$(6)\ K_m = \frac{Xd_xC_{px} + Yd_yC_{py} + \text{----} + Zd_zC_{pz}}{Xd_xC_{vx} + Yd_yC_{vy} + \text{----} + Zd_zC_{vz}}$$

Where X, Y and Z are volumetric percentages of each gas and d_x, d_y, and d_z are the density of each gas.

Since the values of d_xC_{px} are presented in Table 4 the solution of Equation 6 is extremely simple. Q can be obtained from Figure 3. Because of similarity of values CO, O_2, H_2, and N_2, can be considered one gas.

K TO Q CONVERSION CURVE

FIG. 3

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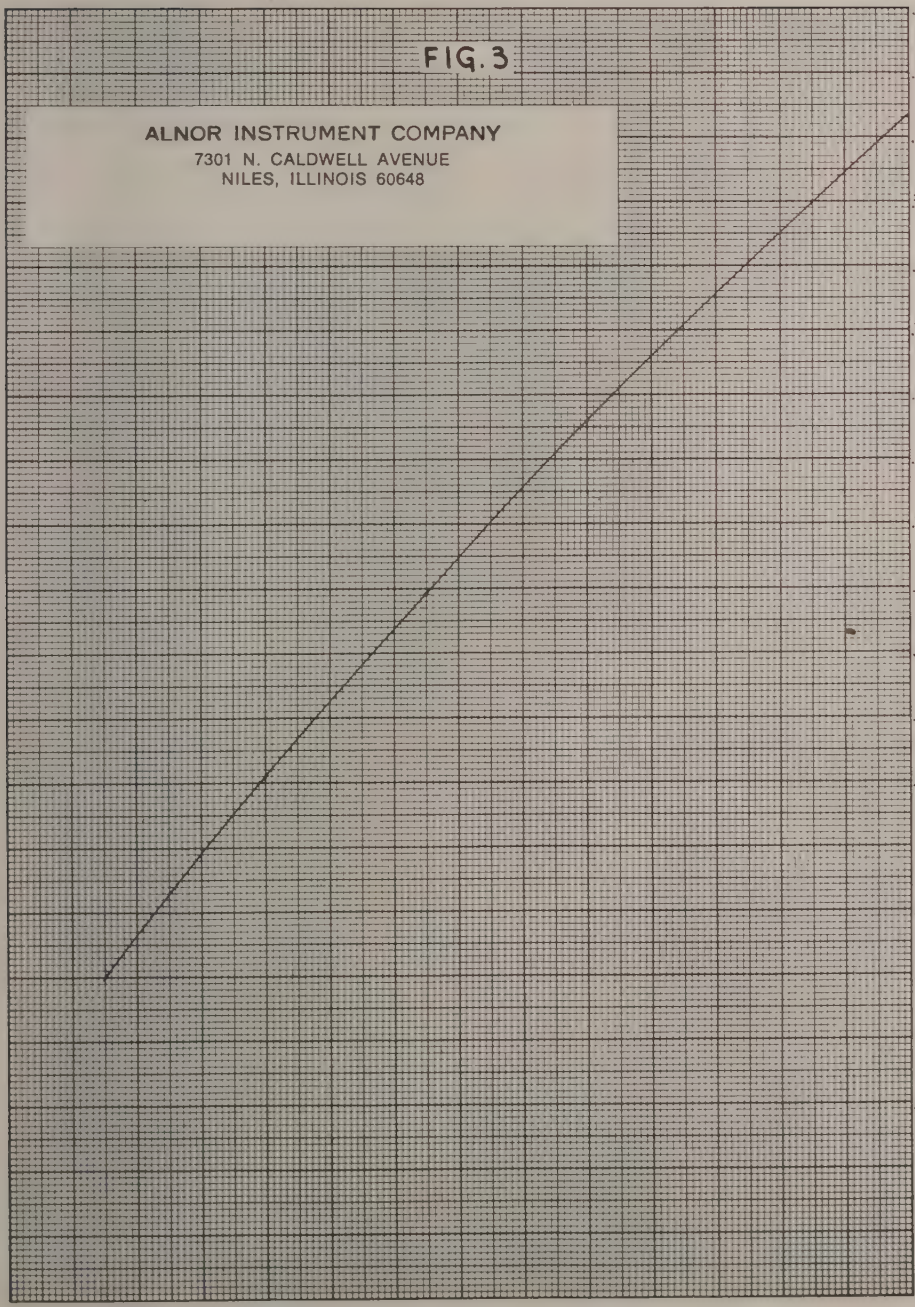


TABLE 4

Gas	Density lbs./c.f. @ 62°F.	C_p B.T.U. per lb.	C_v B.T.U. per lb.	(d)C_p B.T.U. per c.f.	(d)C_v B.T.U. per c.f.	K	Q
CO	.0735	.245	.175	.0180	.0128	1.40	.2855
N_2	.0737	.247	.176	.0182	.0130	1.40	.2855
O_2	.0840	.217	.155	.0182	.0130	1.40	.2855
Air	.0757	.241	.171	.0182	.0130	1.40	.2855
H_2	.00529	3.42	2.44	.0181	.0129	1.40	.2855
CO_2	.1156	.200	.155	.0231	.0179	1.29	.225
CH_4	.0421	.593	.450	.0250	.0190	1.315	.240
He	.01114	1.25	.7530	.0139	.0084	1.660	.400
A	.11135	.125	.0751	.0139	.0084	1.668	.400

Notice that all diatomic gases listed can be treated as a single gas for all practical purposes.

Example for Method 2

A mixture of gases is known to consist of the following:

72% by volume N_2
12.5% by volume of H_2
10% by volume of CO
5% by volume of CO_2
.5% by volume CH_4

Gas	Numerator	Denominator
N_2	.72 (.0182) = .01310	.72 (.0130) = .00936
CO	.10 (.0180) = .00180	.10 (.0128) = .00128
CO_2	.05 (.0231) = .00116	.05 (.0179) = .00090
H_2	.125 (.0181) = .00226	.125 (.0129) = .00161
CH_4	.005 (.0250) = .00013	.005 (.0190) = .00010
	.01845	.01325

Substituting in equation 6, find value of Q

$$K_m = \frac{.01845}{.01325} = 1.392 \qquad Q_m = .281$$

METHOD 3—CURVES

A great many commonly used mixtures primarily consist of only one gas other than diatomic gases. For these mixtures values of Q can be picked off of the curves in Figure 4.

The curves in Figure 4 are plotted for mixtures which consist of percentages of the gas named where the balance of the mixture is N_2, O_2, H_2 or CO. If small percentages of other gases are present, they can be ignored.

EXAMPLE—METHOD 3

Given the mixture specified for the example of Method 2 find the value of Q by use of Figure 4.

Since the values of d (C_p) and d (C_v) are so nearly equal for all the diatomic gases assume that they are actually one gas having the characteristics of N_2. Since the volume of CH_4 is small add it to the CO_2 for this purpose, then the analysis of the gas becomes

5.5% by volume CO_2
94.5% by volume N_2
From Figure 4 Q = .281

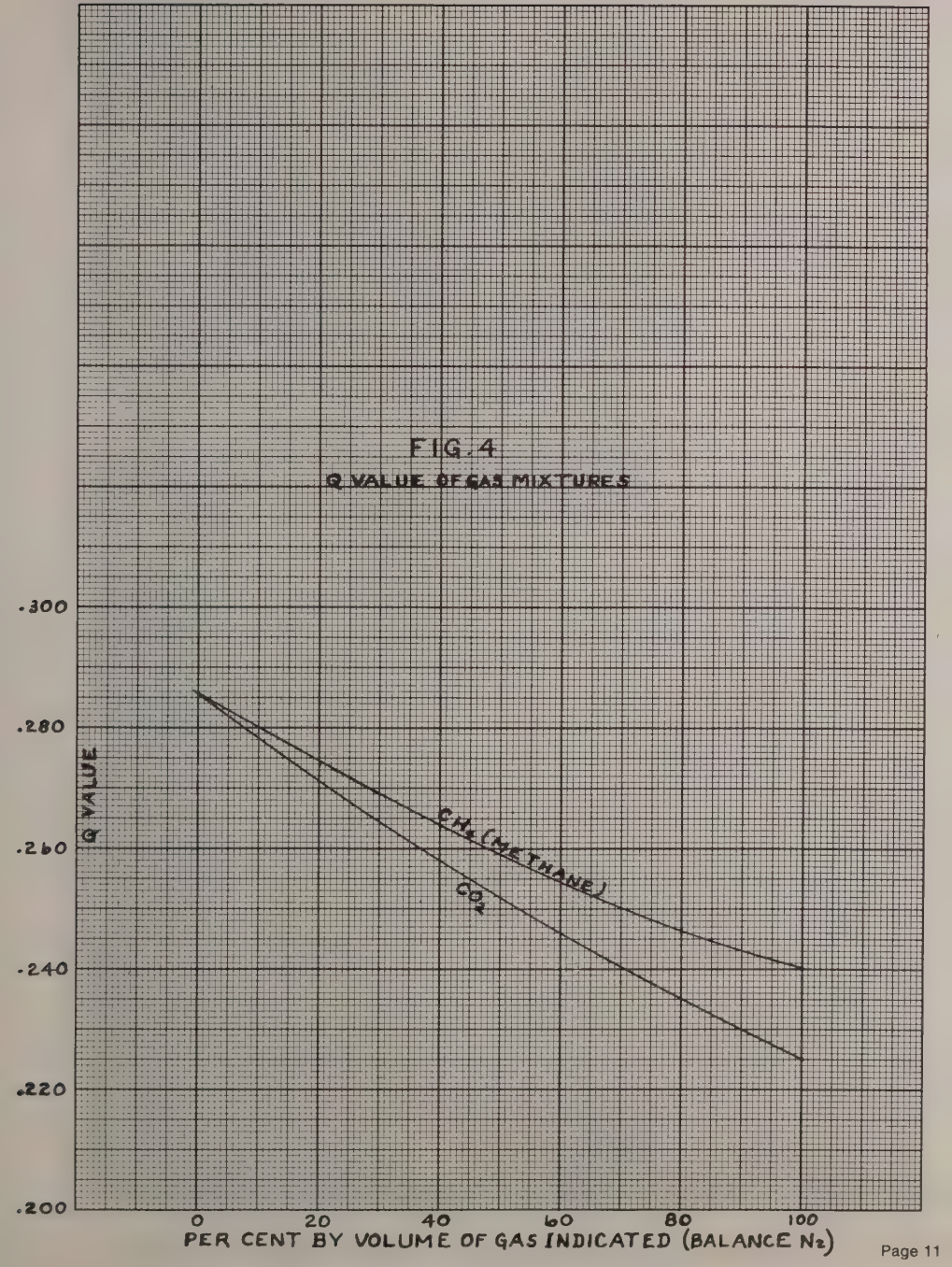


FIG. 4
Q VALUE OF GAS MIXTURES
.300
.280
.260
.240
.220
.200
Q VALUE
CH_4 (METHANE)
CO_2
0
20
40
60
80
100
PER CENT BY VOLUME OF GAS INDICATED (BALANCE N_2)

ACCURACY OF GAS ANALYSIS

The Q value of a mixture of gases is dependent upon the kinds of gases and upon their percentages in the mixture. It is neither feasible nor necessary to make an Orsat analysis before each test of dew point but the *approximate* composition of the mixture should be known. An error of .005 in the Q value will produce an error of about 2 Fahr. degrees when the pressure ratio is 0.4 but this error decreases as the pressure ratio becomes higher.

An apparent error of 10% in the volumetric analysis of CH_4 or an error of 7% in volumetric analysis of CO_2 is generally permissible. It is evident, therefore, that the Alnor Dew Pointer is not dependent on an accurate analysis as far as common mixtures are concerned. To investigate this, one can use the Dew Point Calculator and assume two extreme values of Q (such as 0.22 and 0.32) and a low pressure ratio (such as 0.4) and calculate the two corresponding dew points from some chosen initial temperature.

This was done for an initial temperature of 80°F with the following results. When Q was 0.22, $t_{D.P.}$ = -19°F.; when Q was 0.32, $t_{D.P.}$ = -57.5°F. These two points determine a straight line with a slope, $\frac{\Delta t}{\Delta Q}$ = -385. If one assumes an error in Q of ± .005, he can calculate the error in dew point by multiplying ± .005X (-385) = ± 1.92 degrees. In the first paragraph (above) this was called 2 degrees. Since this multiplying factor changes with the pressure ratio, Table 5 has been prepared to show some of these factors as a function of two initial temperatures and a series of pressure ratios.

TABLE 5

Pressure Ratio	***Initial Temp. 40°F***	***80°F***
.35		-430
.40		-385
.45	-320	-340
.50	-285	-305
.55	-255	-275
.60	-225	-240
.65	-195	-210
.70	-165	-180
.75	-135	-145
.80	-110	
.85	-75	

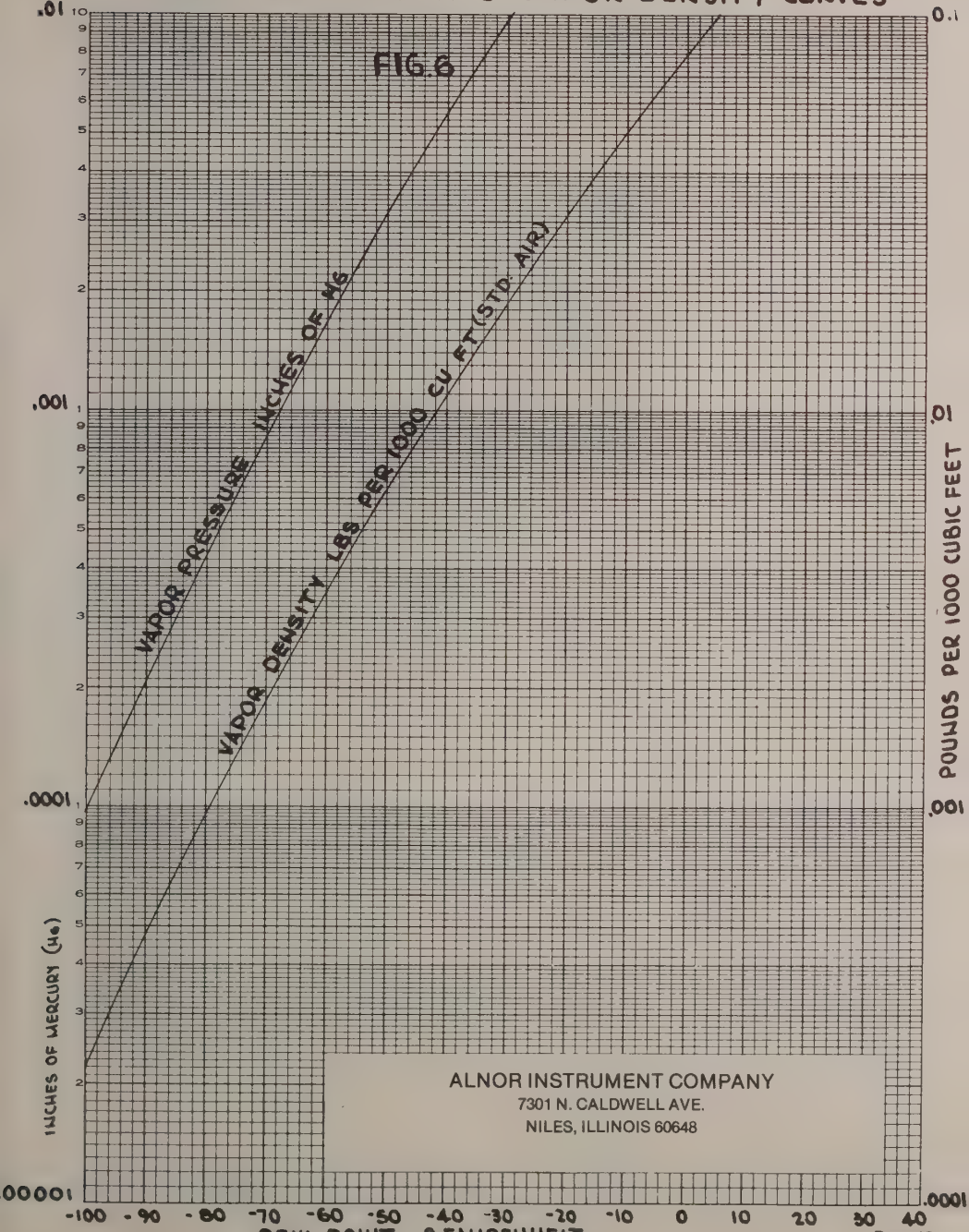
VAPOR DENSITY AND VAPOR PRESSURE

For each dew point there is a corresponding water vapor pressure and water vapor density. The "Alnor" Dew Pointer might just as well have been named a "Vapor Pressure Tester" or "Vapor Density Gauge." The following curves have been provided to permit easy transfer from one set of values to another as the need arises. See Figures 6 and 7.

For dew points below freezing there are theoretically two possible values for vapor pressure, that is, vapor pressure over ice or vapor pressure over water. There is considerable experimental evidence indicating that the vapor pressure of air corresponds with the vapor pressure of sub-cooled water, whether the air is actually in contact with sub-cooled water or with ice. Accordingly the vapor pressures plotted on the following curves correspond with the vapor pressures over sub-cooled water. Vapor densities are plotted on the same basis.

VAPOR PRESSURE AND VAPOR DENSITY CURVES

FIG. 6



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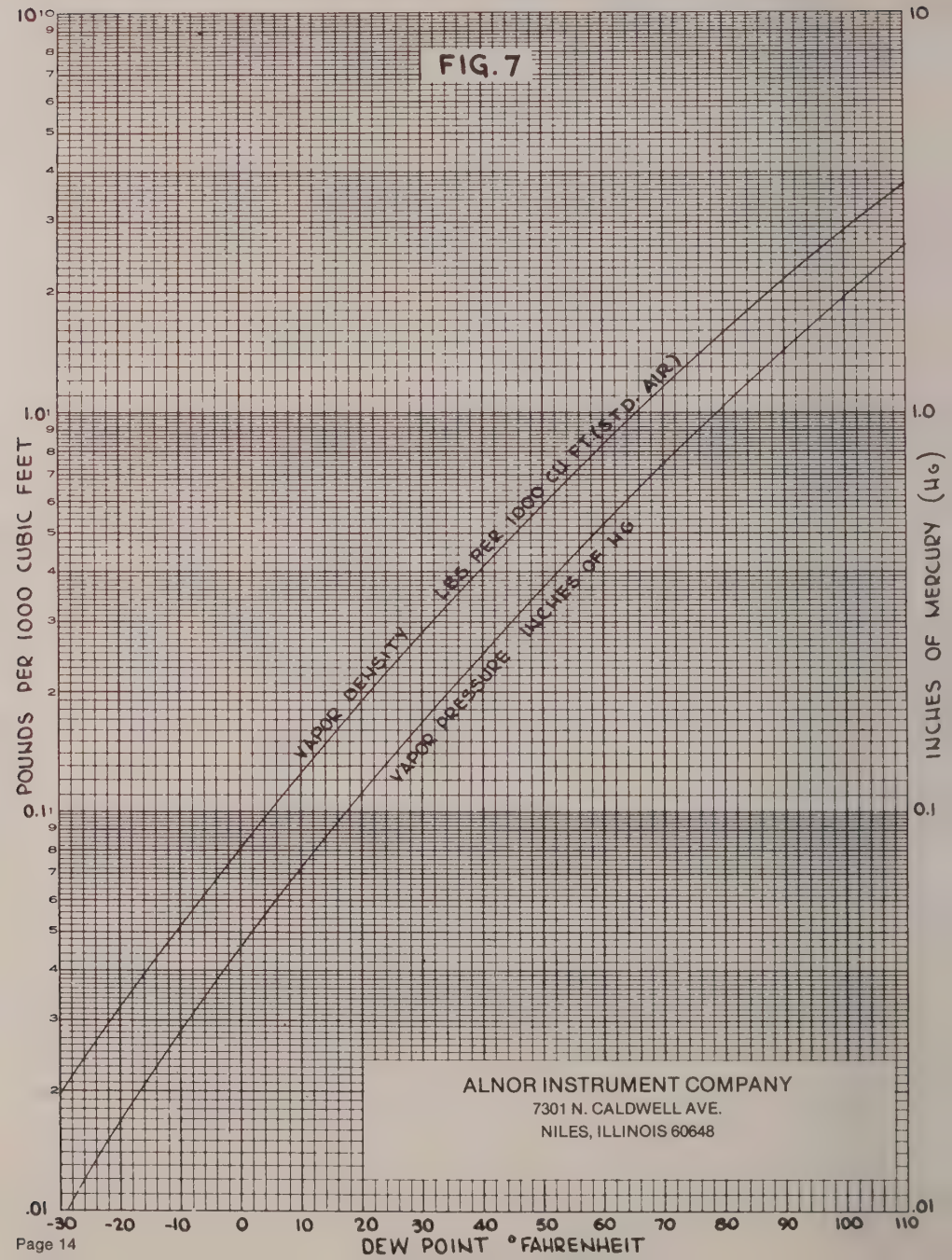
VAPOR PRESSURE AND VAPOR DENSITY CURVES



THE DEW POINTER AS A "GO, NO-GO GAUGE"

For shop use it is frequently desirable to use the Dew Pointer as a Go, No-Go Gauge. In this case the operation of the instrument becomes so simple that comparatively unskilled workmen can use it.

As an example assume a situation where a gas having a Q value of .2855 is carried in a pipe line at 1 pound gauge pressure. The process is to be operated so that the dew point is kept below 0°F. By performing the operations in reverse order the Dew Point Calculator can be used to develop a chart as follows:

Assume a series of reasonable initial temperatures as shown in the following table. Then set arrow 1 at the first initial temperature on scale E. On scale D read the limiting pressure ratio opposite the critical dew point temperature. Continue this process with each of the chosen initial temperatures. Record each of the computed pressure ratios.

FOR 0°F. DEW POINT
Q = .2855

Thermometer	*Pressure Ratio Gauge*
70	.61
72	.60
74	.59
76	.583
78	.577
80	.57

The instrument can be left connected to the gas line continuously with the purge valve cracked so that a small amount of gas is bleeding thru continuously. Thus no additional purging would be required. All the operator would have to do is read the thermometer—close the purging valve—pump the instrument up to the indicated pressure ratio—pause for fifteen seconds—and press the operating valve. If a fog appears, the dew point is above 0°F.

DEW POINTS AT ELEVATED PRESSURES

If a sample of gas is compressed it is apparent the vapor pressure is increased. The compressed gas, therefore, has a higher dew point that corresponds to the new vapor pressure.

The "Alnor" Dew Pointer gives the dew point at atmospheric pressure. When the corresponding dew point at higher pressure is required refer to Figure 8.

EXAMPLE: A gas is carried in a pipe line at 585 pound gauge pressure. The "Alnor" Dew Pointer indicates the dew point is –65°F. What is the actual dew point in the pipe line.

Answer is 1°F.

PSYCHROMETRIC CHART

Figure 9 shows the relationship between dew point temperatures, dry bulb temperatures, and relative humidity in the low humidity regions which are difficult to read on the usual psychrometric chart. The "Alnor" Dew Pointer is particularly useful for making humidity measurements in this comparatively dry region.

Relative humidity is by definition the ratio of the actual vapor pressure of water vapor (the saturated vapor pressure at the dew point) in an air-vapor mixture to its saturated vapor pressure at the dry bulb temperature.

Relative humidity may also be defined as ratio of the weight of water vapor in one cubic foot of the mixture as indicated by its dew point, to the weight of water vapor in one cubic foot of a saturated mixture at the dry bulb temperature.

EXAMPLE:

Dry Bulb Temperature 80°F.
Dew Point Temperature 0°F.
What is the Relative Humidity?
Answer from Figure 9 4.4%

Figure 10 is a standard Psychrometric Chart. In addition to dew point temperatures, dry bulb temperatures and relative humidity, it shows wet bulb temperatures, grains of water vapor per cubic foot, grains of water vapor per pound of dry air and the volume of the mixture in cubic feet of mixture per pound of dry air.

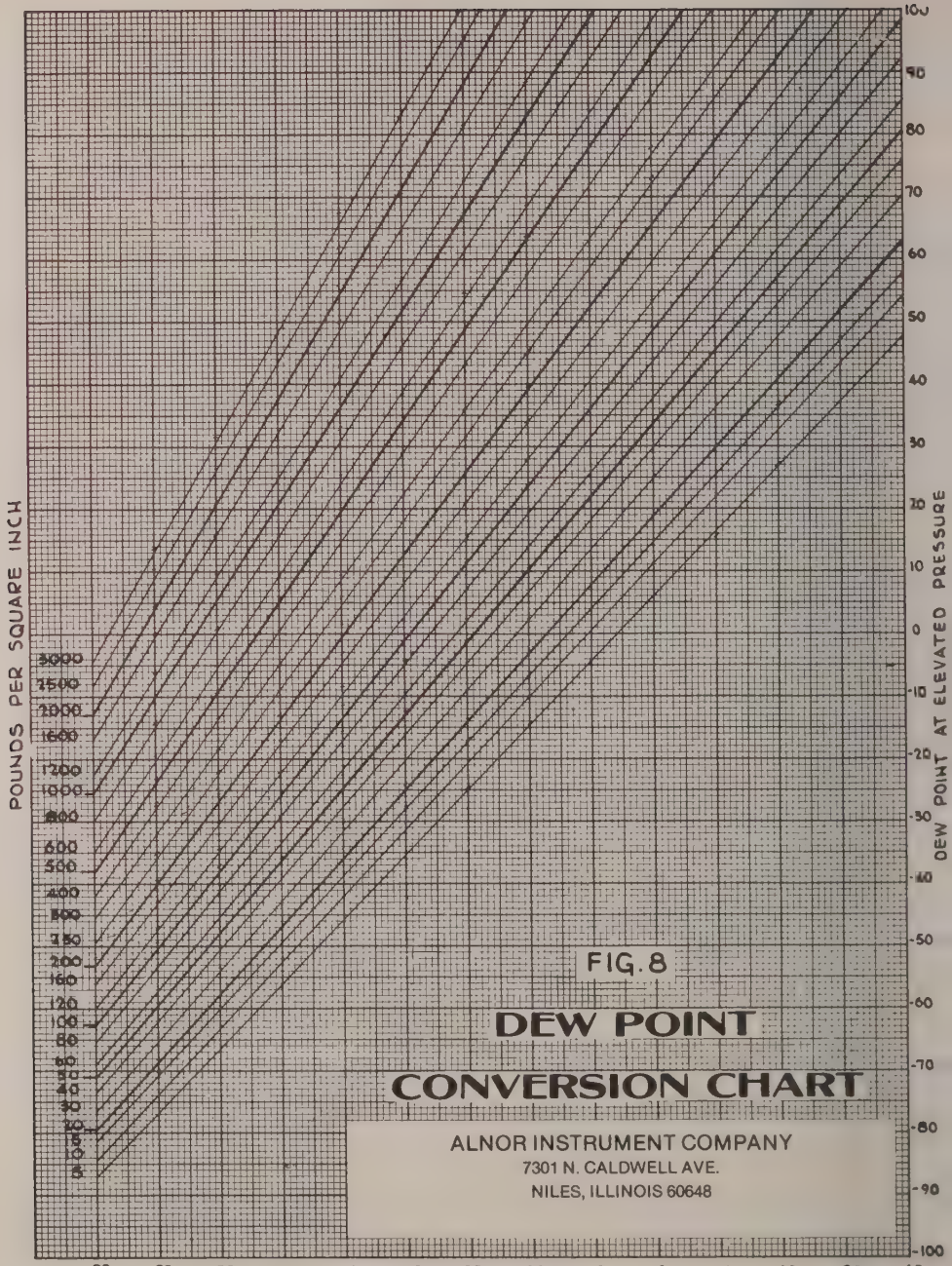
EXAMPLE:

Dry Bulb Temperature 90°F.
Dew Point Temperature 50°F.

What other values can be read from the Psychrometric Chart?

ANSWER:

Wet Bulb Temperature 65°F.
Relative Humidity 25%
Volume of the Mixture
14.0 cu. ft. per lb. of dry air.
Density of the vapor
4.11 grains per cu. ft.
Weight of the vapor
53.4 grains per lb. of dry air.


POUNDS PER SQUARE INCH
3000
2500
2000
1600
1200
1000
800
600
500
400
300
250
200
160
120
100
80
60
50
40
30
20
15
10
5
DEW POINT AT ELEVATED PRESSURE
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40
INDICATED DEW POINT
FIG. 8
DEW POINT
CONVERSION CHART
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NILES, ILLINOIS 60648

PSYCHROMETRIC CHART

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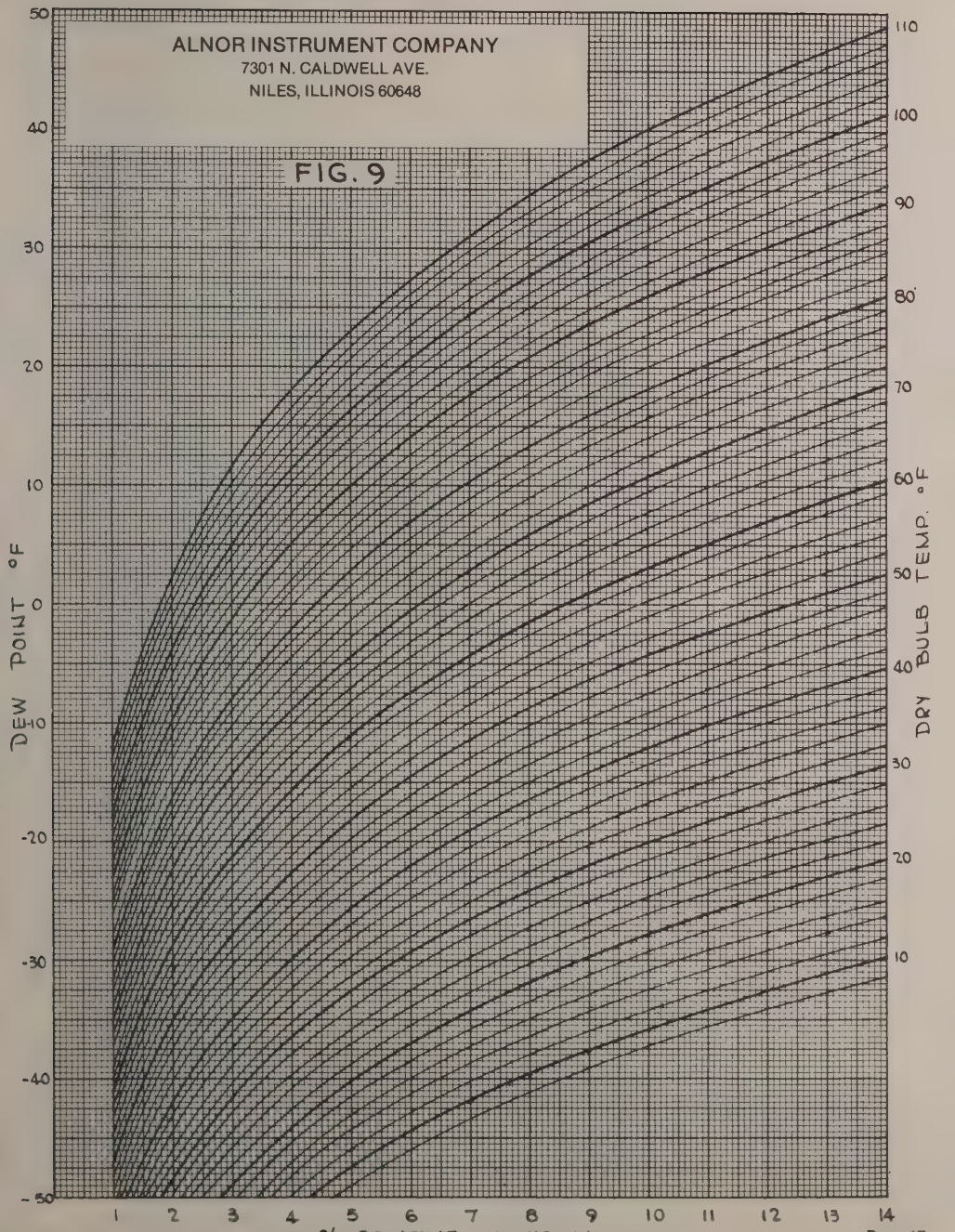
FIG. 9



PSYCHROMETRIC CHART

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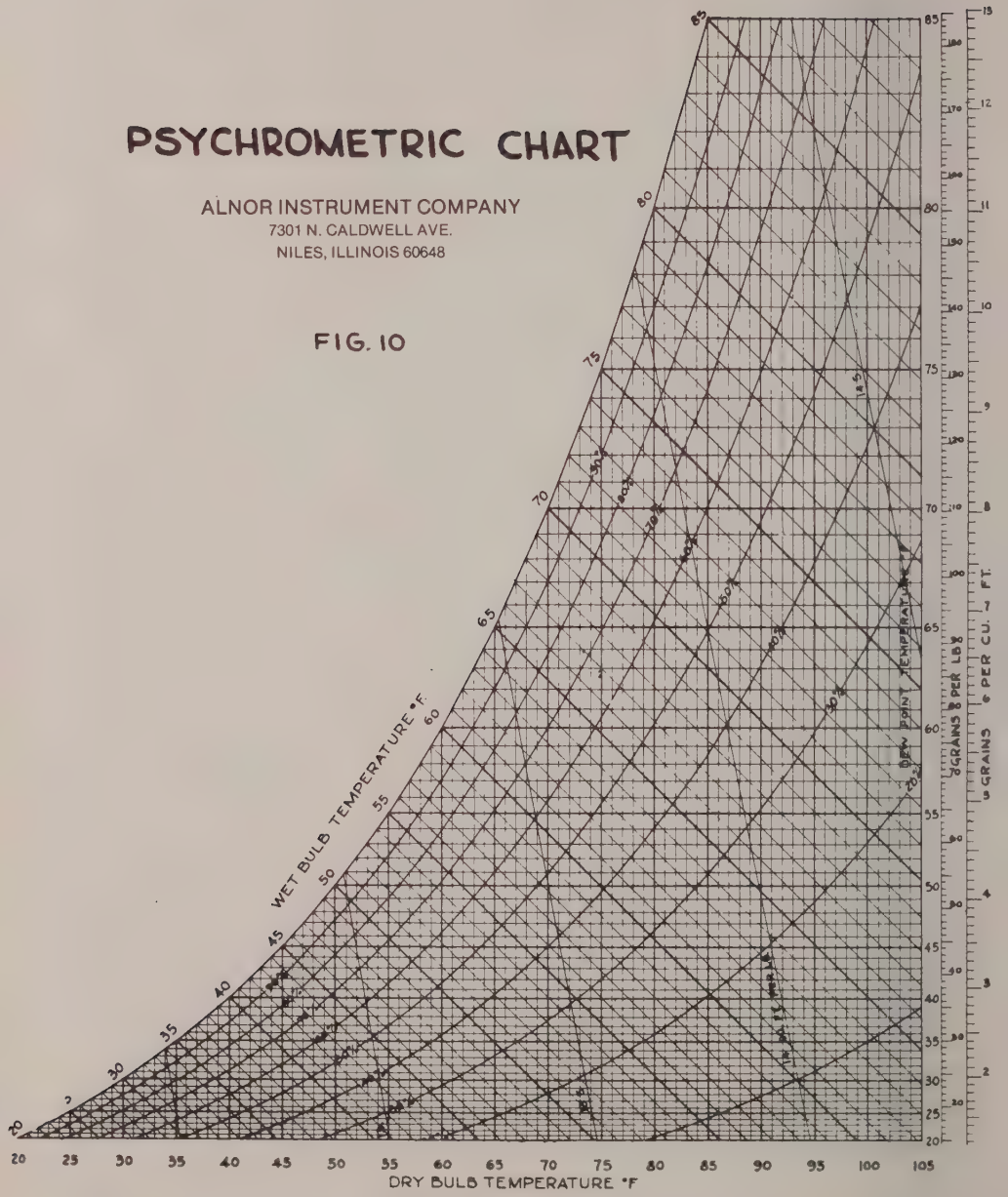
FIG. 10


WET BULB TEMPERATURE °F.
DRY BULB TEMPERATURE °F
DEW POINT TEMPERATURE °F
GRAINS PER LB
GRAINS PER CU. FT.
20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105

MAINTENANCE AND SERVICE NOTES FOR ALNOR DEW POINTERS

Most Important! Keep your Dew Pointer clean and well lubricated.

1. *Filter*—Check the fiber glass filter material frequently and replace it as soon as it begins to darken. This is important because the dirt on the glass fibers holds moisture. Be sure the screen and disk are in place at the bottom of the filter barrel.
2. *Air in Pressure Ratio Gauge*—Bubbles appear in the fluid column of the pressure ratio gauge after the instrument has been transported or has been used to measure hydrogen gas. These bubbles can be freed by pumping up the column and then releasing the pressure with the purging valve. It is helpful to turn the unity adjuster to near the top of its travel and to tip the Dew Pointer about 45 degrees to the left while working the pump. Have the operating valve out and the purging valve closed. Tipping the instrument to the left or to the front will help bring out the bubbles.
3. *Replacing Lost Manometer Fluid*—When fluid is accidentally blown out through the manometer valve, this valve must be removed and cleaned as in Par. 7 below. New fluid must be added as follows:
   a. Have purging valve open and operating valve up.
   b. Remove the knurled cap of the OIL REFILL and take out the needle screw.
   c. Set the unity adjuster to its mid position.
   d. Tilt the instrument case to the left.
   e. Depress the gauge valve and hold it while adding fluid to the filling well from the dropper spout on the plastic fluid bottle. Release the gauge valve before removing the spout from the well. Add fluid to bring the column up to the 1.0 mark of the manometer scale. Tighten the needle screw in place before attempting to operate the Dew Pointer.
   f. When refilling an oxygen Dew Pointer, use only #7231C manometer fluid. DO NOT USE THE STANDARD FLUID.
4. *Leaks*—To operate correctly, the Dew Pointer must be free of leaks in its tubes, valves, and fittings. Pump the fluid column up near its top and close all
- valves. The height should remain fixed except for temperature changes. If the column drifts down, try to observe the rate of drift. Press down on the operating valve and again observe the rate of drift.
   a. If the fluid appears stable, the leak is in the fog chamber or the piping to it. Suspect the gaskets at the window and the lens. Tighten the caps by hand to compress their soft gaskets. If necessary, replace the gaskets.
   b. If the leak persists and seems a little faster with the operating valve pressed down, the leak is in the operating valve itself, the pump discharge valve, the purging valve, or the tubing connections to the reservoir. The purging valve can be reseated by tightening the needle screw into the seat. Looseness in the packing of the operating valve can be taken up by tightening the top cap. The piping joints can be tested with a soap solution or "Leak-Tec" or "Seamtest Concentrate" solution.
   c. When installing new filter material, be sure no glass fibers remain outside the chamber or under the gasket. A leak here will contaminate the air sample.
5. *Operating Valve*—The operating valve requires little maintenance besides occasional tightening of the top cap. When it is necessary to disassemble the valve, be sure to follow Fig. C carefully when reassembling. Lubricate all the pieces with petroleum jelly in the standard instrument. Be sure to use the silicone grease on the oxygen Dew Pointers.
6. *Fog Chamber*—Keep window and lens clean. Replace gaskets as they begin to leak. If the fog chamber becomes dirty or corroded, send it to the manufacturer for cleaning and polishing. The Radium foil is mounted in the fog chamber and is NOT TO BE TOUCHED OR BENT. Most state laws governing radio-active materials forbid the touching of such materials. They must be worked only by trained employees who are being monitored for radio-active exposure.

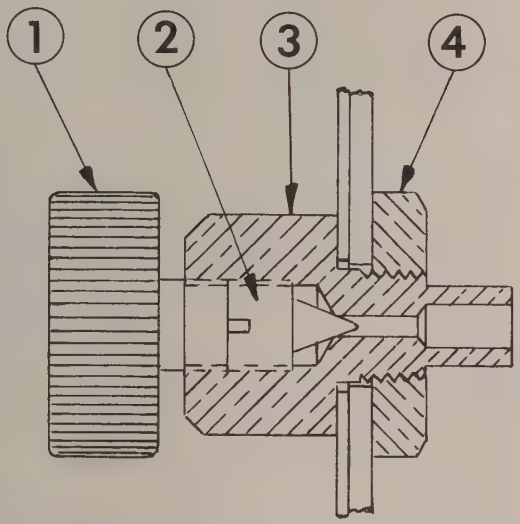
7. *Ratio Gauge*—If the manometer fluid is accidentally blown out through the gauge valve, this valve must be removed and washed with mineral spirits to dissolve the fluid. Remove the pushbutton assembly using an open-end wrench. Use a ½" spanner or two small screwdrivers to unscrew the valve assembly from the manometer block. DO NOT TRY TO OPERATE THE DEW POINTER WHEN FLUID IS LOW OR VALVE IS REMOVED.

   Refer to Fig. E when replacing parts in the ratio gauge assembly. Be sure the "O" ring is in place when inserting the manometer valve assembly. Tighten the valve against the "O" ring just enough to prevent leaking but avoid cracking the block. Tighten the pushbutton assembly just enough to prevent turning since it does not seal against pressure. Replace two "O" rings to stop leaks at the unity adjuster. Tighten the nut just enough to prevent turning since the block can be cracked easily.

Warning about Oxygen Dew Pointers
When servicing an oxygen Dew Pointer, you must use the special "O"-rings, lubricant, and manometer fluid listed at end of the Parts List. Using standard parts, you will ruin the Pressure Ratio Gauge.

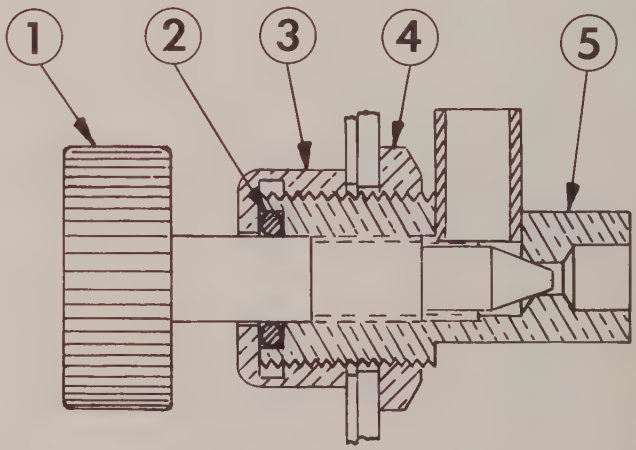
8. *Reservoir*—If diaphragm is damaged (usually stretched) the oil column in the pressure ratio gauge will not come up to the right pressure and excessive pumping becomes necessary and the correct Dew Point cannot be obtained. The diaphragm is a Mylar Film. This material is very tough and it is most improbable that a rupture will occur. However, depressing the gauge valve when the instrument is under pressure may stretch the diaphragm. This may also result from pumping when the operating plunger is depressed. If this happens the diaphragm must be replaced. In most of these cases, the instrument should be sent back to the manufacturer for cleaning and repair.
9. *Pump*—All essential components of the pump are shown in Fig. F. Basically there is a barrel, piston, and four valves. The gas to be tested enters from the filter and some of it flows through a tube to the chamber above the piston. It is sucked into that part of the pump as the piston is pushed down. When the piston is raised, the gas passes out to the outlet fitting. This keeps the barrel walls covered with the gas under test, but that portion of gas may be contaminated with small amounts of outside air carried in on the piston rod. Uncontaminated gas passes through the two lower valves, the operating valve, and into the fog chamber where it can be tested. One small particle of dirt in any one of these four valves will prevent the pump from working properly.
   a. To check inlet valve (from filter), set fluid column at unity on the scale. Pump ten full strokes and see whether the fluid column rises above .45. If more than twelve strokes are needed, the reservoir diaphragm is stretched or the inlet valve is leaking. Remove the nut and push the tubing to one side. Unscrew the valve screw and take out all the pieces of the valve. Clean all the pieces and inspect for damage. Follow Fig. F and install all good pieces; then tighten the valve screw securely. Re-connect the copper tubing.
   b. To check the outlet valve (to operating valve) pump up the fluid column to .4 on its scale and observe the fluid column. If there is a slow downward drift in two minutes and a faster drift after the operating valve is pressed, there is a leak in the outlet valve. Remove and clean the parts of the valve, being sure to follow Fig. F when putting the parts back into the valve.
   c. Keep the piston and "O" ring clean and lubricated with petroleum jelly. Replace the ring if it has any imperfection.
10. *Oxygen Dew Pointers*—When ordering parts for the oxygen Dew Pointers, ALWAYS specify that the parts are to be used in the oxygen meters. When performing the service operations, avoid using the standard lubricant, manometer fluid, and "O" rings. See the special parts list at end of manual.

OIL REFILL ASSEMBLY #7010
(556-046-001)
FIGURE A

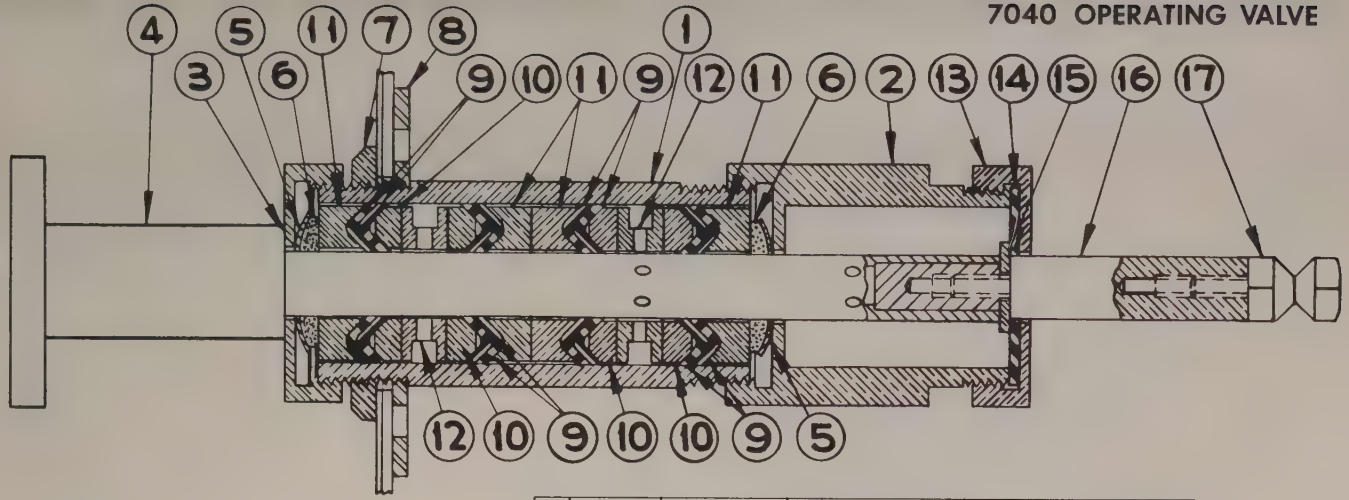


ITEM NO.	PART NO.	NEW PART NO.	NO. REQ'D.	DESCRIPTION
4	7014	300-006-006	1	REFILL VALVE NUT
3	7011	300-001-009	1	REFILL BLOCK
2	7012	300-002-004	1	NEEDLE SCREW
1	7013	300-003-000	1	REFILL VALVE CAP

PURGING VALVE ASSEMBLY #7020
(556-005-008)
FIGURE B



ITEM NO.	PART NO.	NEW PART NO.	NO. REQ'D.	DESCRIPTION
5	7015A	556-003-007	1	PURGING VALVE ASSEMBLY
4	7022	300-011-003	1	PURGING VALVE NUT
3	7016	300-008-007	1	VALVE CAP
2	7021	342-001-001	6 SPARES EXTRA	"O" RING
1	7019	556-004-002	1	PURGING SCREW ASSEMBLY



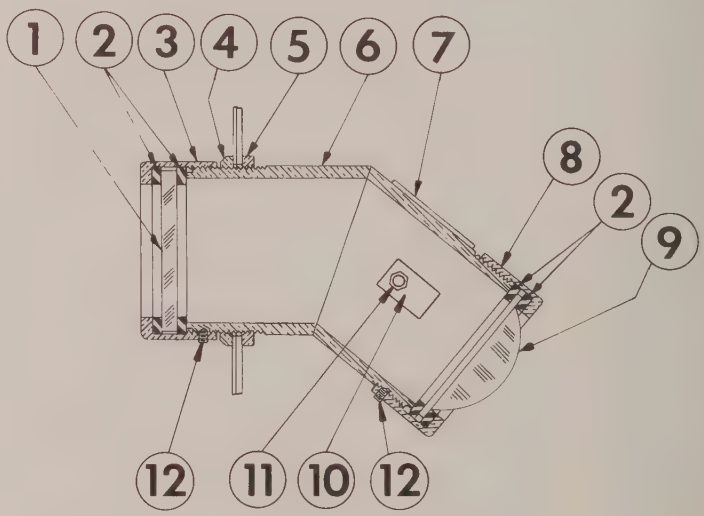
ITEM NO	PART NO	NEW PART NO	AMT REQD	DESCRIPTION	REMARKS
17	7047	300-022-003	1	SWITCH SCREW	
16	7063	300-023-009	1	VALVE EXTENSION	
15	7046	300-021-008	1	VALVE STOP WASHER	
14	7064	339-004-005	1	CHAMBER GASKET	
13	7038	300-017-006	1	VALVE CAP	
12	7039	300-018-001	2	VALVE SPACER	
11	7042	300-020-002	4	FEMALE "V" RING	
10	7041	300-019-007	4	MALE "V" RING	
9	7043	339-002-004	8	HYDRAULIC "V" RING	
8	7036	308-004-014	1	VALVE BARREL FLANGE	
7	7037	300-016-000	1	VALVE BARREL RING	
6	7045	339-003-000	2	VALVE WASHER	
5	7044	246-001-001	2	SPRING WASHER	
4	7030	556-007-009	1	PLUNGER ASSEMBLY	
3	7038A	300-017-013	1	VALUE CAP	
2	7035	556-010-005	1	OPERATING CHAMBER	
1	7032	556-009-000	1	VALVE BARREL ASSEMBLY	

OPERATING VALVE ASSEMBLY #7040

(when ordering, specify type and serial no.)

FIG. C

FOG CHAMBER ASSEMBLY #7060A
(556-013-001)
FIGURE D

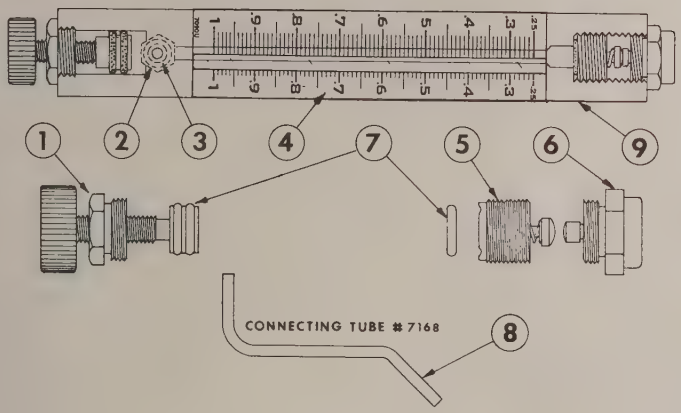


RATIO GAUGE ASSEMBLY #7065

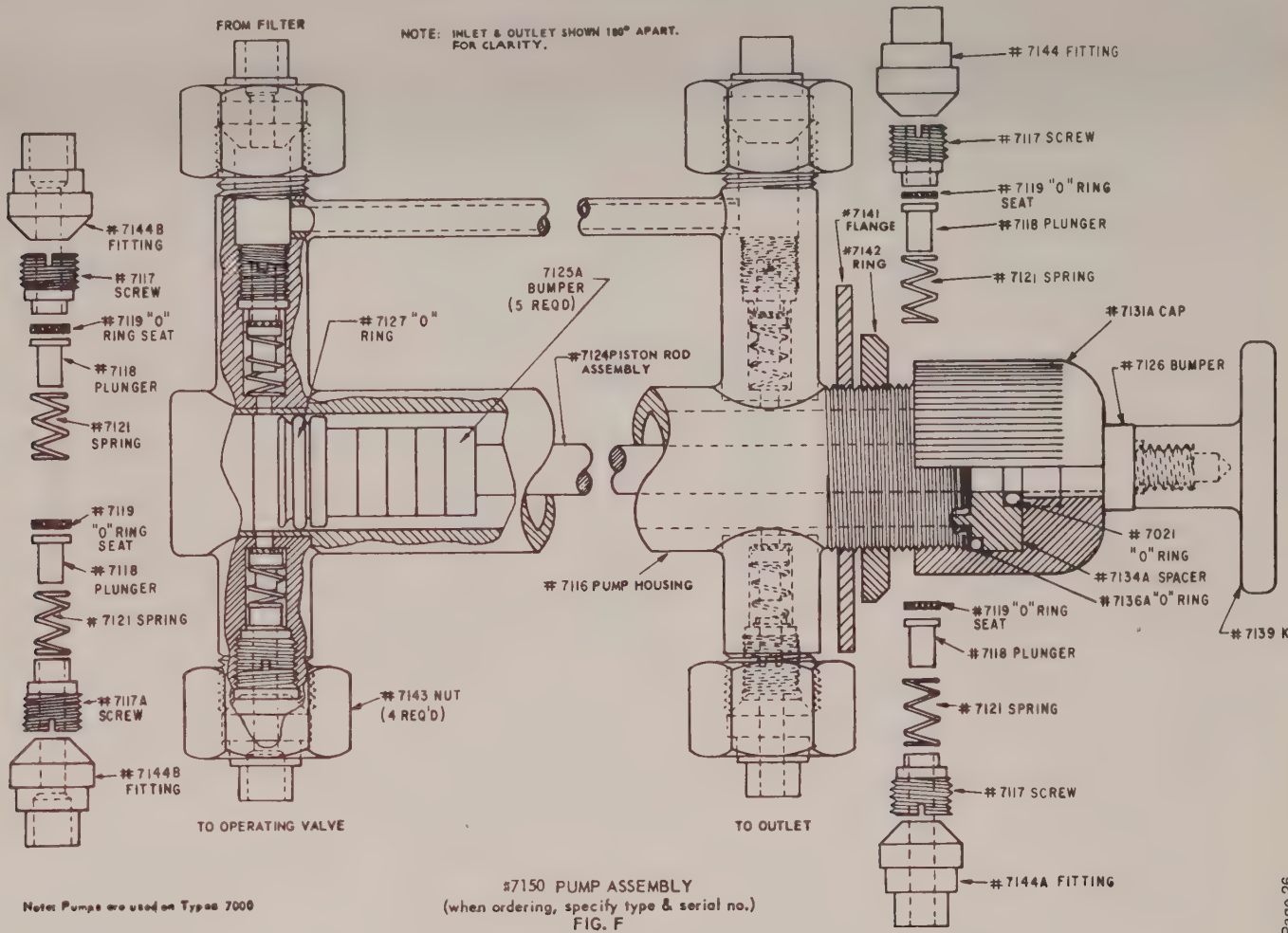
(556-014-007)

FIGURE E

(*) SUFFIX DENOTES RANGE



ITEM NO.	PART NO.	NEW PART NO.	NO. REQ'D.	DESCRIPTION
9	7062	314-001-033	1	MANOMETER BLOCK
8	7168	315-016-006	1	CONNECTING TUBE
7	7068	342-002-007	3	"O" RING
6	7084	556-019-004	1	PUSHBUTTON
5	7078	556-018-009	1	VALVE
4	7092*	556-SERIES*	1	SCALE
3	7086	342-003-002	1	"O" RING
2	7085	355-001-001	1	COUPLING FITTING
1	7070	556-016-008	1	UNITY ADJUSTER ASSEMBLY



#7150 PUMP ASSEMBLY
(when ordering, specify type & serial no.)
FIG. F

Note: Pumps are used on Types 7000

FIG. G

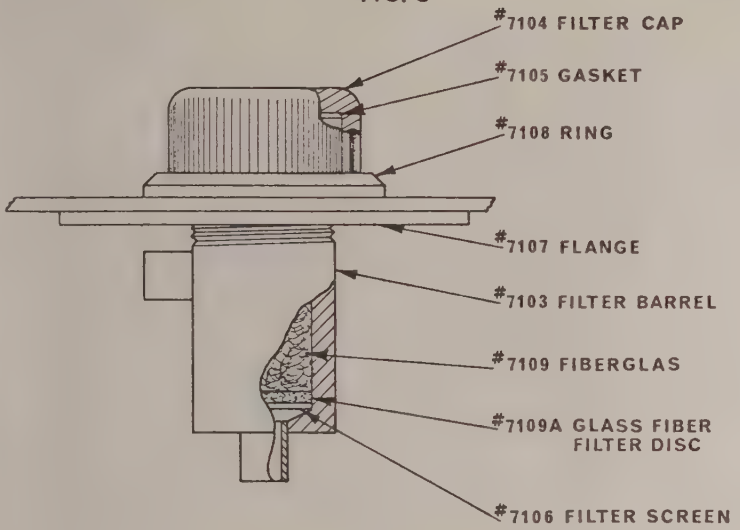
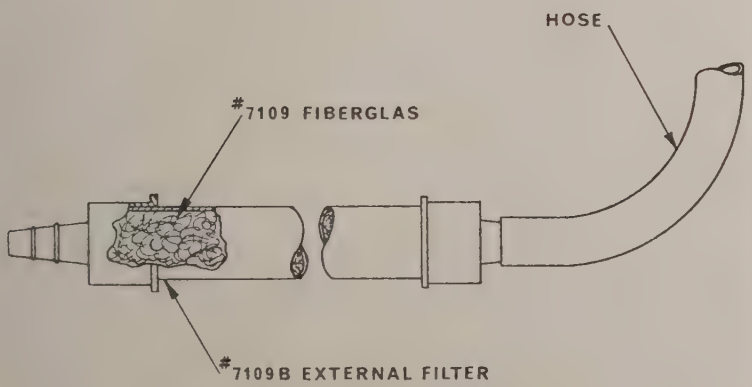

#7104 FILTER CAP
#7105 GASKET
#7108 RING
#7107 FLANGE
#7103 FILTER BARREL
#7109 FIBERGLAS
#7109A GLASS FIBER FILTER DISC
#7106 FILTER SCREEN

FIG. H


HOSE
#7109 FIBERGLAS
#7109B EXTERNAL FILTER

TROUBLE SHOOTING CHART FOR "ALNOR" DEW POINTER

OBSERVED DEFECT	PROBABLE FAULT	REMEDY
Air bubbles in pressure ratio gauge	rough handling	see para. 2.
Fluid in P.R. gauge falls while under steady pressure	leaks in system or leak at pump outlet valve	see para. 4a. see para. 4b & c.
Fluid in P.R. gauge rises while under steady pressure	leak in P.R. gauge valve	replace the P.R. gauge valve. see para. 7.
Pump does not work freely	lack of lubrication	Remove old grease then re-lubricate. see para. 9.
Excessive pumping required	restriction in supply line to Dew Pointer or damaged diaphragm	remove the restriction. see para. 8.
Fluid in P.R. gauge must be replaced frequently	leak at unity adjuster or at comp. fitting fitting behind gauge.	replace O-rings on unity adj. see para. 7.

PARTS LIST FOR ALNOR DEWPOINTER TYPE 7000

IMPORTANT: Be sure to state clearly when you are ordering repair parts for the OXYGEN Dewpointers.

Assembly or Part Number	Description
7009	Inlet Fitting
7010	Oil Refill (See Fig. A.)
	7012 Needle screw (for 7010 only)
	7013 Cap (for 7010 only)
	7014 Nut
7020	Purging Valve (See Fig. B)
	7015A Valve housing
	7016 Cap (for 7020 only)
	7019 Needle screw (for 7020 only)
	7021 "O" ring (for 7020, pk. of 6)
	7022 Nut
7040	Operating Valve (See Fig. C.)
	7030 Plunger
	7032 Valve barrel
	7035 Chamber
	7036 Flange
	7037 Ring
	7038 Cap (unplated)
	7038A Cap (plated)
	7039 Spacer (pk. of 2)
	7041 "V" ring (male, pkg. of 8)
	7042 "V" ring (female, pkg. of 8)
	7043 "V" ring (hydraulic, pkg. of 8)
	7044 Spring washer (pkg. of 4)
	7045 Felt washer (pkg. of 4)
	7046 Stop washer
	7047 Switch screw
	7063 Extension
	7064 Gasket
7060A	Fog Chamber
	(See Fig. D-1; S.N. 3850 and above)
	7052A Fog chamber housing
	7053A Bottom lens cap
	7053B Top lens cap
	7055A Flange
	7056A Ring
	7057A Gasket (pkg. of 12)
	7059A Chamber lens
	7061A Window
7065	Ratio Gauge Assembly*
	(See Fig. E.)
	7062 Manometer block*
	7068 "O" ring (pkg. of 12)
	7070 Unity adjuster
	7084 Pushbutton assembly
	7078 Manometer valve assembly
	7085 Manometer coupling
	7086 "O" ring (pkg. of 12)
	7092 Scale assembly*
	7168 Tubing
	*When ordering, specify "U", "H", or "L".
7101	Reservoir Assembly
	7096 Reservoir
	7098 Reservoir cover
	7099 Diaphragm (pkg. of 6)
7110	Filter Assembly (See Fig. G.)
	7109A Filter disk (pkg. of 100)
	7109B External Filter
	7104 Filter cap
	7105 Filter gasket
	7106 Filter screen
	7235 Fiberglas (boxed)
	7107 Flange
	7108 Ring
7150	Pump Assembly (for 7000 only; See Fig. F; S.N. 1800 and above)
	7116 Pump housing (with valves)
7120	Spare Parts Group for 7150
	3, 7117 Check Valve Screws
	1,7117A Check Valve Screws
	12,7118 Check Valve Plungers
	12, 7119 Check Valve Seats
	12, 7121 Check Valve Springs
	6, 7127 Piston "O" rings
	7124 Piston rod assembly
	7125A Piston bumper (pkg. of 2)
	7126 Piston bumper
	7144 Pump fitting
	7144A Pump fitting
	7144B Pump fitting (pkg. of 6)
	7139 Pump knob
	7141 Pump flange
	7142 Pump ring
	7143 Fitting nut (pkg. of 4)

Assembly or Part Number	Description
7138	Pump Cap Assembly (For Ser. No's below about 19000) 7134 Spacer 7136 Cap gasket (pkg. of 6) 7021 "O" ring (pkg. of 6)
	Pump Cap Parts (For Ser. No's above about 19000) 7131A Cap 7134A Spacer 7136A "O" ring (pkg. of 3) 7021 "O" ring (pkg. of 6)

MISCELLANEOUS PARTS

7151 Thermometer shield
7152 Thermometer base
7153 Thermometer protection tube
7154 Thermometer, 40°F to 120°F
7154A Thermometer, 0°C to 50°C
7154B Thermometer, -30°F to 110°F
7359 Toggle switch
7363 Panel wiring assembly
7362 Case wiring assembly
7190 Mercury switch assembly
7186 Switch spring assembly
7189 Mercury switch
7192 Hose nipple with #7143 nut
7193 Tubing nipple with #7143 nut

Assembly or Part Number	Description
7203	Lamp arm bracket
7204	Lamp bracket
7205	Lamp socket
7368	Lamp, 6v. (pkg. of 2)
7207	Lamp protection bracket
7369	Transformer
7370	Battery
7371	Battery bracket
7373	Power receptacle, 115v.
7372	Power cable, 115v.
7219	Plastic tubing, 3 ft. long
7229	Open end wrench
7230B	Calculator
7231	Manometer fluid (4 oz. container)
7235	Fiberglass filter medium (one box)
7202	Case (Specify serial number.)
7353A	Micro-switch assembly for replacement
7374	Power cable, 230v.
7375	Power receptacle, 230v.

SPECIAL PARTS FOR OXYGEN DEWPOINTERS

7068A "O" ring (pkg. of 12)
7086A "O" ring (pkg. of 12)
7078A Manometer valve assembly
7231C Manometer fluid (4-oz. container)
2060 Stopcock grease (Silicone lubricant for operating valve handling oxygen)

— NOTES —

ALNOR INSTRUMENT COMPANY
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NILES, ILLINOIS 60648

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